

LONDON- WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA9 | Central Chilterns

Flood risk assessment (WR-003-009)

Water resources

November 2013

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Department
for Transport

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

- 1.1.1 The water resources and flood risk assessment appendices comprise three parts. The first of these is a route-wide appendix (Volume 5: Appendix WR-001-000).
- 1.1.2 Specific appendices for each community forum area (CFA) are also provided. For the Central Chilterns area (CFA9) these are:
- a water resources assessment (Volume 5: Appendix WR-002-009); and
 - a flood risk assessment (i.e. this appendix).
- 1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5, Water Resources and Flood Risk Assessment Map Book.

1.2 Scope of this assessment

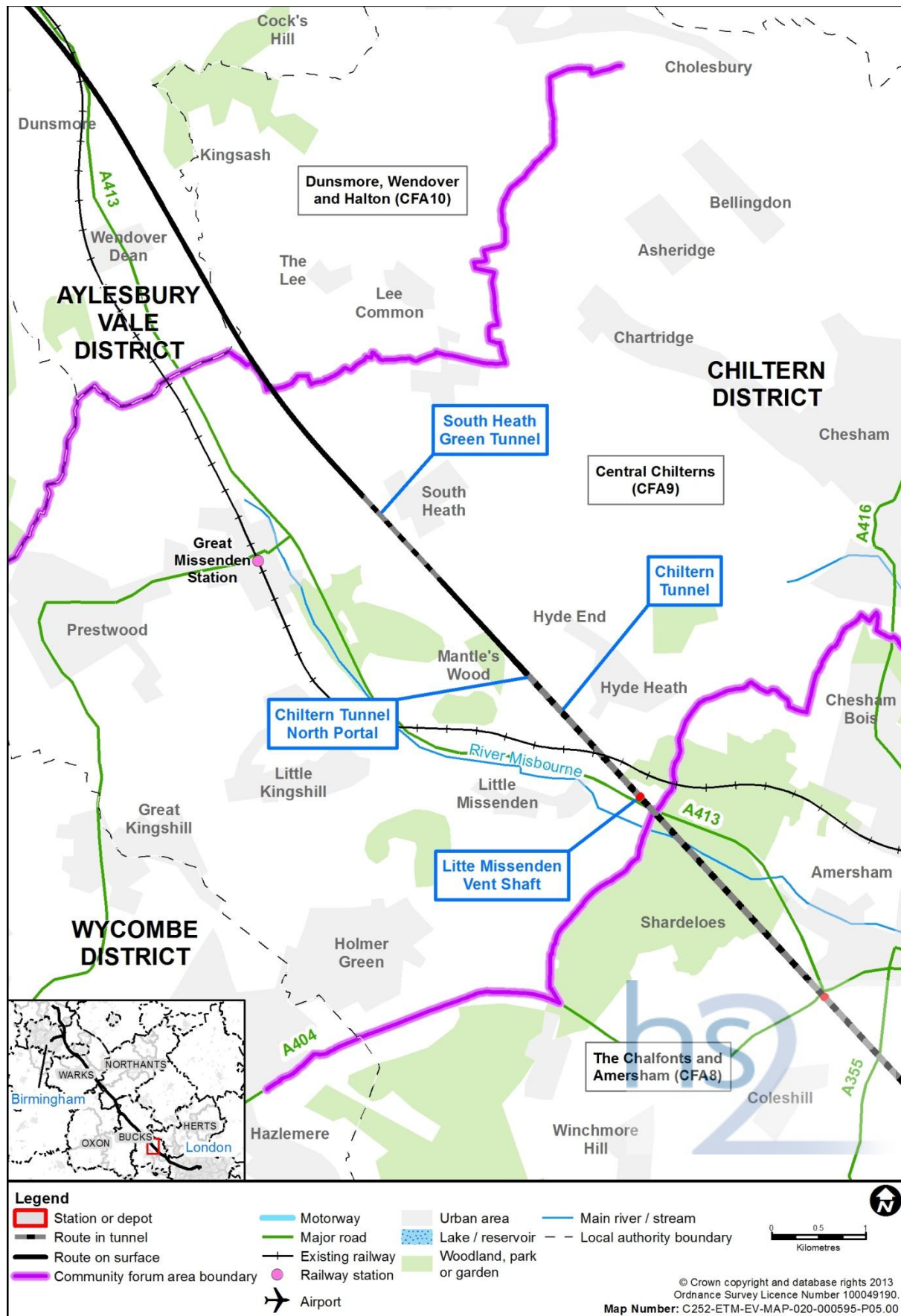
- 1.2.1 This flood risk assessment (FRA) considers the assessment of flood risk in CFA9. The assessment has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF)¹ which aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe without increasing flood risk elsewhere.
- 1.2.2 The FRA methodology and a review of the relevant local planning policy documents are provided in Section 2 of this report. The design criteria are provided in Section 3 and Section 4 documents the sources of information that have been reviewed. Section 5 provides a description of the planned works within CFA9. Section 6 considers baseline flood risk and the risk of flooding to the Proposed Scheme from all relevant sources. Flood risk mitigation measures included within the Proposed Scheme are detailed in Section 7. The effect of the Proposed Scheme on the risk of flooding is considered in Section 8.

1.3 Location

- 1.3.1 CFA9 covers an approximately 6.1km section of the Proposed Scheme in the Chiltern district of Buckinghamshire. It extends from the junction of the A413 with Mop End Lane to Leather Lane and passes to the east of Little Missenden and Great Missenden, as shown in Figure 1. The Chalfonts and Amersham area (CFA8) and Dunsmore, Wendover and Halton area (CFA10) lie respectively to the south and to the north.

¹ Department for Communities and Local Government (2012), *National Planning Policy Framework*.

Figure 1: Central Chilterns area



- 1.3.2 The study area extends to a distance of 1km from the centre line of the route and includes the parishes of Little Missenden and Great Missenden as well as the south-western edge of Chartridge to the north of Hyde Heath. It extends from the boundary between Amersham and Little Missenden parishes in the south-east to the boundary of Great Missenden, Wendover and The Lee parishes in the north-west. The corresponding council wards are Little Missenden, Ballinger, South Heath and Chartridge, and Great Missenden.
- 1.3.3 The Proposed Scheme will not cross any formal watercourses within CFAg. The River Misbourne, however, flows in a north-west to south-east direction through the study area to the south of the route.

2 Flood risk assessment methodology

2.1 Source-pathway-receptor model

- 2.1.1 Flood risk is assessed using the source-pathway-receptor model. In this model individual sources of flooding within the study area are identified. The primary source of flooding is rainfall which is a direct source in the short-term (surface water runoff) and can lead to flooding from watercourses (river flooding) and overloaded man-made collection systems (sewer flooding) in the short or medium-term. Stored rainfall, either naturally in below ground aquifers and natural lakes or artificially in impounded reservoirs and canals, can lead to flooding when the storage capacity of the system is exceeded. A final source of flooding arises from tidal effects and storm surges caused by low pressure systems over the sea.
- 2.1.2 For there to be a risk of flooding at an individual receptor there must be a pathway linking it to the source of flooding. The pathways within the study area are assessed by reviewing national datasets that show the spatial distribution of flood risk. The associated risk magnitude is then categorised.
- 2.1.3 Receptors considered in this assessment include the Proposed Scheme and existing development within 1km of the Proposed Scheme. The Proposed Scheme includes all associated permanent infrastructure. Areas of interest are identified through comparison of the national spatial datasets with the design drawings. Where a risk is identified mitigation is proposed in line with recommendations in the NPPF.
- 2.1.4 Existing receptors within the study area are identified using Ordnance Survey (OS) mapping information. A high-level screening assessment is then undertaken to identify receptors that are within or in close proximity to an area of flood risk via pathways indicated using the flood risk data sources listed below. The vulnerability of each receptor is classified using Table 2 of the NPPF Technical Guidance Document².
- 2.1.5 The assessment then considers the vulnerability of the receptor with reference to the flood risk category of the source using Table 3 of the NPPF Technical Guidance Document and assesses whether the Proposed Scheme has any potential to influence or alter the risk of flooding to each receptor. Where such potential has been identified, mitigation is proposed based on further analysis.

2.2 Flood risk categories

- 2.2.1 The level of flood risk is categorised by assessing the design elements against the datasets for each source. A matrix showing the flood risk category associated with each flooding source is presented in Table 1.

² Department for Communities and Local Government (2012), *National Planning Policy Framework Technical Guidance*.

Table 1: Flood risk category matrix for all flooding sources

Source of flooding	Flood risk category				
	No risk	Low	Medium	High	Very high
Rivers		Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Surface water	No surface water flooding.	Surface water flooding <0.3m for 1 in 200 years event.	Surface water flooding >0.3m for 1 in 200 years event; and Surface water flooding <0.3m for 1 in 30 years event.	Surface water flooding >0.3m for 1 in 30 years event.	
Groundwater		Very low-low	Moderate	High-very high	
Drainage and sewer systems	No sewer in vicinity of site.	Surcharge point >20m from site and no pathways.	Surcharge point within 20m of site and restricted pathways.	Sewer network crosses site and pathways exist.	
Artificial sources	Outside of inundation mapping/no pathway exists.	Within inundation mapping/ pathway exists.			

2.3 Regional and local flooding planning policy documents

- 2.3.1 Under the Flood and Water Management Act 2010³, the lead local flood authority (LLFA) for the study area is Buckinghamshire County Council (BuCC). The recommendations from the BuCC Preliminary Flood Risk Assessment (PFRA)⁴, undertaken in accordance with the Flood Risk Regulations 2009⁵, have been reviewed in undertaking this assessment. The draft BuCC Local Flood Risk Management Strategy (LFRMS)⁶ is at the consultation stage and was published in February 2013. The local planning authority for the study area is Chiltern District Council (ChDC). The local development framework (LDF) Core Strategy was adopted in November 2011.

Buckinghamshire County Council Preliminary Flood Risk Assessment

- 2.3.2 The BuCC PFRA confirms that there are no indicative flood risk areas of national significance within the Buckinghamshire area. Consequently, only Stage 1 of the Flood Risk Regulations 2009 process (i.e. the PFRA) has been completed.
- 2.3.3 The most significant historical flood event in Buckinghamshire was caused by high groundwater levels across the chalk aquifers resulting in high river flows and widespread groundwater flooding in the valleys of the Chiltern Hills. The flooding

³ Flood and Water Management Act 2010 (c.29). London, Her Majesty's Stationery Office

⁴ Jacobs and Buckinghamshire County Council (2011), *Buckinghamshire County Council PFRA*

⁵ Flood Risk Regulations 2009 (SI 2009 No.3042). London, Her Majesty's Stationery Office

⁶ Buckinghamshire County Council (2013), *Buckinghamshire County Council Local Flood Risk Management Strategy 2013 - 2018*

occurred in the winter of 2000/2001 and is considered to have had "significant harmful consequences".

- 2.3.4 The BuCC PFRA recognises that the construction and engineering of the Proposed Scheme may have a significant impact upon surface water flows. For example embankments and cuttings may, without suitable design solutions, impede the flow of small watercourses and surface runoff.

Buckinghamshire County Council Local Flood Risk Management Strategy

- 2.3.5 The BuCC LFRMS⁷ guides the planning process in relation to flood risk across all categories. The LFRMS outlines key policies in relation to development within Buckinghamshire. Specific policies of relevance to the Proposed Scheme are:

- "Policy 6 – the LLFA will seek to reduce the risk of flooding now in a way which does not compromise the interconnected needs of the economy, society and environment in the future"; and
- "Policy 15 – sustainable drainage systems (SuDS) should be used in new developments to reduce the rate and volume of surface water. Design of SuDS to meet national standards and to be adopted by the SuDS Approval Body. SuDS are expected to provide natural removal of pollutants and sediments, promote aquifer recharge, enhanced biodiversity, add aesthetic value and be easily maintainable."

Thames Region Catchment Flood Management Plan

- 2.3.6 The River Misbourne flows through the study area and is a tributary of the River Colne. This watercourse falls within the Thames Region Catchment Flood Management Plan (CFMP)⁸ which covers the extent of the Thames basin. The main focus of the plan concerns the high risk of flooding to key urban centres that predominantly lie downstream of the study area and the predicted future increase in flood risk due to climate change.
- 2.3.7 The Thames Region CFMP sub-area four covers chalk and downland catchments and includes the Colne tributaries, Wye, Middle Mole, Thame and Upper Lee. Proposed actions for these catchments include maintaining the existing river system capacity and looking for opportunities to make it more efficient and to work with local planning authorities to retain remaining floodplain and increasing public awareness.

Chiltern District Council Strategic Flood Risk Assessment

- 2.3.8 The ChDC Level 1 strategic flood risk assessment (SFRA)⁹ and supporting mapping has recently been updated. The ChDC SFRA provides key information and advice on planning policy within the development area and is used as a basis for policy setting and planning decisions.

⁷ Buckinghamshire County Council (2013), *Buckinghamshire County Council Local Flood Risk Management Strategy 2013 – 2018*.

⁸ Environment Agency (2007), *Thames Region Catchment Flood Management Plan*

⁹ Jacobs (2013), *Chiltern District Council Strategic Flood Risk Assessment Level 1 Update*

- 2.3.9 The updated ChDC SFRA focuses on detailed mapping of critical drainage areas which are most at risk of flooding from surface water, groundwater and ordinary watercourses. The ChDC SFRA policy states that in these areas SuDS solutions should be a priority.
- 2.3.10 The ChDC SFRA also records historical incidences of flooding from all sources. The predominant source of flooding within the area covered by CFA9 is from the River Misbourne in Great Missenden and Little Missenden. The ChDC SFRA also indicates that surface water flooding has occurred in Great Missenden and South Heath in the past and suggests that rising groundwater levels in the Great Missenden area have exacerbated the impact of localised flooding.
- 2.3.11 The ChDC SFRA includes policy recommendations for the ChDC Core Strategy, suggesting the following priorities:
- consider adaptations to climate change;
 - promote integrated flood risk management and sustainable management of land and local flood risk;
 - improve recording of flood incidents;
 - promote the use of SuDS including at homeowner level to reduce urban creep; and
 - improve communication and involvement of partners, stakeholders and the general public.
- 2.3.12 As an overall policy, the ChDC SFRA recommends promoting development and designs that reduce the overall risk of flooding and seeks to ensure that development results in a positive reduction in flood risk to the district through reducing the frequency or severity of flooding.
- 2.3.13 The ChDC Level 2 SFRA¹⁰ was completed in June 2008 following the initial Level 1 report. Potential development sites are reviewed in light of the findings of the ChDC Level 1 SFRA and a summary of potential risks is provided to inform the sequential test. The primary objective of this ChDC Level 2 SFRA is to ensure that the risk of flooding can be realistically mitigated through the design process. Outcomes of the assessment conclude that it is imperative that the development control process emphasises the critical importance of flood risk, influencing the design process accordingly.

Core Strategy for Chiltern District

- 2.3.14 The Core Strategy for Chiltern District¹¹ forms part of the LDF and was adopted in November 2011. It is the overarching plan in the LDF and contains planning policy of specific relevance to flood risk and development covering the following points:
- sites in Flood Zones 2 and 3 are not suitable for development since the capacity of the floodplain will be reduced and the flow of floodwater impeded.

¹⁰ Jacobs (2008), *Chiltern District Council SFRA Level 2*

¹¹ Chiltern District Council (2011), *Core Strategy for Chiltern District*

This will increase the severity of flooding and also increase the risk of flooding elsewhere;

- support will be given to proposals to reduce the vulnerability of existing developments and land uses within the floodplain; and
- consideration of local flooding, as indicated by the ChDC SFRA critical drainage area mapping, should be an integral part of design and measures must be taken to reduce the flood risk.

2.3.15 Policy CS4 outlines measures the council should implement to ensure that development is sustainable, with a focus on the incorporation of SuDS. This is of particular importance in identified critical drainage areas to ensure that development will not increase the risk of flooding within prospective development sites or to adjoining land and properties. It also promotes seeking options to reduce the risk of flooding in appropriate circumstances as part of new development proposals.

3 Design criteria

- 3.1.1 It is a requirement of the design that the Proposed Scheme shall be protected against flooding from any source during the 1 in 1000 years return period (0.1% annual probability) rainfall event, with water levels not rising closer than 1m to the top of rail level.
- 3.1.2 In accordance with the NPPF an allowance for climate change is included in the assessment by assuming that peak rainfall intensity will increase by 30% and that peak river flows will increase by 20%.

4 Data sources

4.1 Primary datasets

- 4.1.1 Consistent with the requirements of the NPPF this assessment considers the risk of flooding from rivers, direct surface water runoff, rising groundwater, overwhelmed drainage and sewer systems, and artificial sources such as reservoirs, lakes and canals.
- 4.1.2 The Proposed Scheme lies entirely outside the extent of flooding from the sea and therefore the risk of flooding from tidal sources is not considered in this assessment.
- 4.1.3 The primary datasets for each source of flooding used to assess the design elements are presented in Table 2. A high-level review of the risk of flooding and potential impacts is undertaken on the basis of these datasets across all flood sources. Where this review indicates potentially significant impacts on the risk of flooding, or a risk of flooding to the route, further investigation in the form of hydraulic modelling is undertaken.

Table 2: Flood risk assessment data sources

Source of flooding	Datasets reviewed	Data owner
Rivers	Flood zone mapping. Detailed River Network. Catchment hydraulic models.	Environment Agency
Surface water	Flood Map for Surface Water (FMfSW). Local surface water flood mapping.	Environment Agency LLFA
Groundwater	Areas susceptible to groundwater flooding. 1:50,000 geological mapping (superficial and bedrock). Potential for elevated groundwater.	British Geological Survey LLFA
Drainage and sewer systems	Sewer network plans. Lost river location plans.	Water companies (various) Local planning authority
Artificial sources	Reservoir inundation mapping (RIM). Canal infrastructure locations. Trunk water main asset plans.	Environment Agency Canal & River Trust Water companies (various)

4.2 Site familiarisation visits

- 4.2.1 No site familiarisation visits were undertaken within this study area.

5 The proposed development

5.1 Topography and land use

- 5.1.1 The character within the study area is rural landscape interspersed with areas of woodland and isolated farmsteads and dwellings. The predominant land use is mixed agriculture. Settlements within the area include Little Missenden, Great Missenden, Little Kingshill, Hyde Heath and South Heath.
- 5.1.2 The topography is generally hilly with a distinct ridgeline running south-east to north-west roughly parallel to and to the east of the Proposed Scheme. To the south-west of the ridgeline the land drops steeply to the River Misbourne in the valley below. The Proposed Scheme lies entirely within the Chilterns Area of Outstanding Natural Beauty.
- 5.1.3 The River Misbourne and its tributaries flow along the western edge of CFAg through the villages of Great Missenden and Little Missenden. The Proposed Scheme does not cross the River Misbourne within the study area.

5.2 Local flood risk receptors

- 5.2.1 The vulnerability of each local receptor with an identified pathway within the study area is presented in Table 3. The vulnerability is classified in accordance with the recommendations of Table 2 in the NPPF Technical Guidance Document and the Scope and Methodology Report (SMR) (see Volume 5: Appendix CT-001-000/1) and the SMR Addendum (see Volume 5: Appendix CT-001-000/2).

Table 3: Vulnerability of local receptors in CFAg

Local receptor	Description	Vulnerability classification	Source/pathway
Kennel Farm	Surface water and river flood risks to land and rear access. Groundwater risk to property	More vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Groundwater - very high
Parkview Cottages	Residential dwellings	More vulnerable	Groundwater - high
Lime Farm	Lime Farm Cottage and access to Lime Farm (Main Farmhouse)	More vulnerable	Surface water 30 years - deep Groundwater - high
Little Missenden village	Residential dwellings, farms and commercial properties in the village centre, including Village Hall, School, The Crown Inn public house and bed and breakfast, The Red Lion public house	More vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Groundwater - very high
Chalk House	Residential dwelling alongside A413	More vulnerable	Groundwater - very high

Local receptor	Description	Vulnerability classification	Source/pathway
Hyde Heath village	Residential properties along southern side of Weedon Hill, Harvest Bank and along Brays Meadow	More vulnerable	Surface water 200 years - deep
Braysgate (No. 1 +2) and Oakley	Residential dwellings on Chalk Lane	More vulnerable	Surface water 30 years - deep
Spindle's Farm	Residential dwelling and associated outbuildings and land	More vulnerable	Surface water 30 years - shallow
The Green, Hyde Heath	The Old Chapel and other residential properties on The Green, Hyde Heath	More vulnerable	Surface water 200 years - shallow
Bullbaiters Lane	Access and residential dwellings on Bullbaiters Lane	More vulnerable	Surface water 30 years - deep
Hyde Farm	Outbuildings and land associated with Hyde Farm and neighbouring Rowan Farm	Less vulnerable	Surface water 30 years - shallow
Chapel Farm	Residential dwellings and associated outbuildings	More vulnerable	Surface water 30 years - shallow
Ballinger Road	Residential dwellings and associated gardens	More vulnerable	Surface water 30 years - deep
Great Missenden village	Residential dwellings and properties including Great Missenden Church of England School, public car park and electricity substation	More vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep
Buryfield House	Residential dwelling and associated land	More vulnerable	Surface water 200 years - shallow
Aylesbury Road	Residential dwellings and associated gardens including The Downs, Berry Thorn, The Poplars and Chesden	More vulnerable	Surface water 200 years - shallow
Black Horse Cottages	Residential dwellings and gardens including Black Horse Cottages and neighbouring properties	More vulnerable	Surface water 30 years - shallow
Town End Farm and Black Horse public house	Residential dwelling and associated land and outbuildings adjacent to public house	More vulnerable	Surface water 30 years - deep
Laurel Lodge	Residential dwelling along Aylesbury Road	More vulnerable	Surface water 30 years - deep
The Lodge	Residential dwelling	More vulnerable	Surface water 30 years - deep
Mapridge Cottage	Residential dwelling	More vulnerable	Surface water 30 years - deep

5.3 Description of the Proposed Scheme

- 5.3.1 The Proposed Scheme through the study area will be approximately 6.1km in length. The key elements of the scheme are described below and shown in Map CT-06-030 to Map-06-034 (Volume 2, CFA9 Map Book).
- 5.3.2 The Proposed Scheme will enter CFA9 in twin-bored tunnel approximately 1.9km in length and 20m to 50m below ground level, continuing to the Chiltern tunnel northern portal at Mantle's Wood west of Hyde Heath. The tunnelled section will include one ventilation and intervention shaft (vent shaft) at Little Missenden. The vent shaft will include a shaft headhouse building and associated hardstanding and landscaping. The Chilterns auto-transformer station will also be located adjacent to the vent shaft.
- 5.3.3 The route will continue in cutting to Chesham Road where the Proposed Scheme will enter the 1.2km long South Heath green tunnel. From north of Frith Hill the route will be in cutting to Leather Lane, to the west of Ballinger Common, where the route will leave this area.

6 Existing flood risk

6.1 Historical flooding incidents

- 6.1.1 The ChDC SFRA and BuCC PFRA both identify specific instances of river flooding from the River Misbourne within Great Missenden, Little Kingshill and Little Missenden. This is the predominant source of flooding within the study area.
- 6.1.2 The only flood event in Buckinghamshire, aside from river flooding, which is considered to have had 'significant harmful consequences' is the groundwater dominated flood event which occurred in the winter of 2000/2001.
- 6.1.3 The BuCC PFRA identifies three historical surface water flooding incidents within the study area close to the village of South Heath that occurred during 2006 and 2007. The ChDC SFRA also indicates that surface water flooding has occurred in Great Missenden and suggests that rising groundwater levels in the Great Missenden area have, in the past, exacerbated the impact of blocked drains and localised surface water flooding.
- 6.1.4 Thames Water Utilities Limited (TWUL) historical DG5 sewer flooding records show that there have been a very small number of sewer flooding incidents within the study area. These are not recorded precisely within either the ChDC SFRA or BuCC PFRA. The ChDC SFRA data, however, indicates that records relate to instances of flooding of one or two properties only. The BuCC PFRA concludes that sewer flooding across Buckinghamshire generally appears to be sporadic and infrequent.

6.2 Risk of flooding from rivers

- 6.2.1 The Proposed Scheme will not cross any Environment Agency Main Rivers or identified ordinary watercourses. Flood Zone 2 and Flood Zone 3 of the River Misbourne lie within the study area of this CFA, as shown on Map WR-01-011, H6 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The river will not be crossed within CFA9 and the route will be in tunnel where the river is closest to the route. Consequently, there is no significant risk of flooding to the Proposed Scheme from rivers.

6.3 Risk of flooding from surface water

- 6.3.1 The Proposed Scheme will cross a number of dry valleys and ditches within the study area that are shown on the Environment Agency FMfSW to be at risk of surface water flooding for both the 1 in 30 years return period (3.3% annual probability) and the 1 in 200 years return period (0.5% annual probability) rainfall events.
- 6.3.2 These dry valleys do not have permanent watercourses but during rainfall events convey overland flow to the downstream catchment of the River Misbourne and are therefore at risk of 'deep' (greater than 0.3m) surface water flooding. Existing conventional rail and highway embankments cross the dry valleys in this area and, as a result of a loss of conveyance, are shown to cause an increased depth and extent of surface water flood risk on the upstream sides.

6.3.3 The most significant dry valleys are:

- immediately south-east of the Little Missenden vent shaft (see Map CT-06-030, D6, Volume 2, CFA9 Map Book) which is at risk of potentially 'deep' surface water flooding for the 1 in 30 years return period (3.3% annual probability) and 1 in 200 years return period (0.5% annual probability) rainfall events;
- at Lime Farm (see Map CT-06-030, A6, Volume 2, CFA9 Map Book) immediately south of the intersection of the Proposed Scheme with the conventional rail embankment south of South Heath. The route will be in tunnel, with no above-ground construction within the area at risk, and consequently there will be no risk of flooding to the Proposed Scheme at this location;
- at Mantle's Wood (see Map CT-06-030, B6, Volume 2, CFA9 Map Book) at the northern entrance to the Chiltern tunnel which is at risk of surface water flooding for the 1 in 30 years return period (3.3% annual probability) and 1 in 200 years return period (0.5% annual probability) rainfall events; and
- at Farthings Wood (see Map CT-06-030, G6, Volume 2, CFA9 Map Book) due east of Hyde Farm where three tributary valleys converge, eventually combining downstream with the flow from the Mantle's Wood dry valley.

Little Missenden vent shaft

6.3.4 There is a well-defined dry valley running from the ridge at Hyde Heath through Lott's Wood and south of Keeper's Wood towards the River Misbourne. The FMfSW shows minor surface water flooding along the base of this valley. The existing raised rail embankment and A413 road embankment restrict natural surface water flows causing ponding. The Proposed Scheme will cross the area of 'deep' surface water flooding upstream of the A413 embankment. The route will be in tunnel at this location and is therefore not at risk of flooding from surface water. The Little Missenden vent shaft, however, will be located immediately north-east of the area shown to be at risk.

6.3.5 Comparison of the Proposed Scheme with the FMfSW risk outlined indicates that the vent shaft will lie outside of the area at risk of flooding from surface water on higher land to the north-east. There is no significant risk of flooding to the Proposed Scheme from surface water at this location.

Mantle's Wood dry valley

6.3.6 At Mantle's Wood the route will cross an area shown on the FMfSW to be at risk of 'deep' flooding from direct surface water runoff during the 1 in 200 years return period (0.5% annual probability) and shallow flooding during the 1 in 30 years return period (3.3% annual probability) rainfall event. The area at risk is associated with two dry valleys that converge immediately upstream of the Proposed Scheme.

6.3.7 The Proposed Scheme will be in cutting at the valley crossing as it emerges from the Chiltern Tunnel. A tunnel portal building will also be located within the cutting.

6.3.8 The ground level is approximately 138m above Ordnance Datum (AOD). The top of rail level at the valley crossing will be 135.2m AOD and is nearly 3m below current

ground levels. Comparison of the FMfSW outlines with ground levels suggests a 1 in 200 years return period (0.5% annual probability) flood level of approximately 139m AOD. There will, therefore, be a risk of flooding to the Proposed Scheme.

- 6.3.9 Surface water flows from the dry valley will be intercepted by the Proposed Scheme land drainage, which will carry flows along the crest of the cutting before descending into a 250m long, 1350mm diameter drop inlet culvert beneath the route. The culvert is designed to convey the 1 in 100 years return period (1% annual probability) rainfall event including a 30% allowance for climate change and allowances for siltation and blockage.

Farthings Wood dry valley

- 6.3.10 At Farthings Wood the route will cross an area shown on the FMfSW to be at risk of deep flooding from direct surface water runoff during both the 1 in 200 years return period (0.5% annual probability) and 1 in 30 years return period (3.3% annual probability) rainfall event. The area at risk is associated with three dry valleys that converge immediately upstream of the Proposed Scheme. Approximately 50m north-east of the main valley crossing the Proposed Scheme will cross the western valley a second time with areas of 'shallow' (between 0.1m and 0.3m in depth) flooding shown on the FMfSW in both return period events.
- 6.3.11 The top of rail level at the valley crossings will be 153.2m AOD and 156.2m AOD with the route falling from low embankment into cutting in a south-north direction. Comparison of the FMfSW outlines with ground levels suggests 1 in 200 years return period (0.5% annual probability) flood levels of approximately 150m AOD and 159–160m AOD. Whilst there would be a freeboard at the main valley crossing of approximately 3m, there will be a risk of flooding to the Proposed Scheme at the western valley crossing.
- 6.3.12 Surface water flows from the dry valleys will be intercepted by the Proposed Scheme land drainage. Flows from the east side of the Proposed Scheme will be collected and discharged within a 1350mm culvert that will be designed to convey the 1 in 100 years return period (1% annual probability) rainfall event including a 30% allowance for climate change and allowances for siltation and blockage. Flows arising from the west side of the Proposed Scheme, including flows from the western dry valley, will be intercepted and diverted south-east along the eastern edge of the cutting to the base of the main valley thereby preventing flooding of the cutting.
- 6.3.13 The Hyde Farm access track and footbridge will also cross all three dry valleys. The overbridge will be raised on embankments to pass over the route and has access limbs that run alongside the route on both sides. The road and footpath levels will be a minimum of 3m and up to 6m above existing ground levels at each crossing of the dry valleys. Consequently there will be no significant risk of flooding to the access track and overbridge from this source.

6.4 Risk of flooding from groundwater

- 6.4.1 The route will not cross any of the areas within CFAg that are shown to have a 'moderate' or greater susceptibility to groundwater emergence. All superficial

deposits along the route of the Proposed Scheme are unproductive. The Proposed Scheme will be in cutting through an area that lies above the Chalk aquifer. The susceptibility to groundwater emergence, however, is classified as 'very low' and, away from the Chiltern and South Heath Tunnels, the cuttings are relatively shallow. The only location where the Proposed Scheme will be below assessed groundwater levels is for approximately 800m at the south of the study area where the route is within the Chiltern tunnel that will be sealed. There is, consequently, no significant risk of flooding to the Proposed Scheme from emergent groundwater.

6.5 Risk of flooding from drainage systems

- 6.5.1 The route will not pass through any urban areas for the full extent within the study area. There will consequently be no risk to the Proposed Scheme of flooding from drainage systems within CFA9.

6.6 Risk of flooding from artificial sources

- 6.6.1 The route will not intersect any areas shown on the Environment Agency RIM to be at risk of flooding in the event of impounded reservoir failure. No further artificial water bodies have been identified within the study area that will constitute a significant risk of flooding to the Proposed Scheme.

6.7 Summary of baseline flood risk

Table 4: Summary of baseline flood risk for all sources of flooding in CFA9

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
Surface water	Little Missenden vent shaft dry valley	High Surface water 30 years - deep	Little Missenden vent shaft	Vent shaft will lie on high land outside of the area at risk.
Surface water	Mantle's Wood dry valley	High Surface water 30 years - shallow	Chiltern tunnel north portal Chiltern tunnel northern approach cutting	Top of rail level will be in cutting below adjacent ground level. Land drainage will be proposed to collect surface water runoff and provide attenuation in a balancing pond.
Surface water	Farthings Wood dry valley	High Surface water 30 years - deep	Chiltern tunnel northern approach cutting	Top of rail level will be 3m above estimated flood water level in eastern valley. Land drainage will be proposed to collect surface water runoff and provide attenuation in a balancing pond. Top of rail will be in cutting below estimated flood water level in western valley. Land drainage proposed to collect surface water runoff and discharge into the downstream watercourse via a balancing pond.
			Hyde Farm access track and footbridge	Road/footpath level will be >1m above estimated flood water level.

7 Flood risk management measures

7.1 Risk of flooding from rivers

- 7.1.1 There are no instances where the Proposed Scheme will be at risk of flooding from rivers within the study area, nor any anticipated effects on the risk of flooding from rivers arising from the Proposed Scheme. No specific management measures will, therefore, be required.

7.2 Risk of flooding from surface water

- 7.2.1 The FMfSW shows the extent of flooding due to rainfall that would occur prior to collection of water into streams or designated drainage infrastructure. By collecting the flows from the dry valley into an adequately designed land drainage system the Proposed Scheme will effectively remove the risk of surface water flooding from the point at which the flow is intercepted thus removing the significant risk of flooding to the Proposed Scheme at Mantle's Wood and the risk at Farthings Wood.
- 7.2.2 Measures to manage the risk of flooding from surface water runoff includes:
- provision of replacement storage and surface water attenuation facilities to restrict peak surface water runoff rates to existing greenfield rates;
 - design of culverts with adequate capacity to convey the 1 in 100 years (1% annual probability) flow including an allowance for climate change; and
 - design of culverts with internal 600mm freeboard and 300mm allowance for siltation to minimise the chances of blockage or future capacity restrictions.
- 7.2.3 There will not be any anticipated changes to the risk of flooding from surface water sources as a result of the Proposed Scheme within the study area. No specific management measures will, therefore, be required.

7.3 Risk of flooding from groundwater

- 7.3.1 There are no locations where the Proposed Scheme will be below ground level within an area with a susceptibility to groundwater flooding, or within deep cuttings through water-bearing strata. Therefore no risk of flooding to the Proposed Scheme is expected and no specific management measures will be required. Similarly, there will not be any significant impact on the risk of flooding from groundwater arising from the Proposed Scheme. No specific management measures will, therefore, be required.

7.4 Risk of flooding from drainage systems

- 7.4.1 There will be no risk of flooding from drainage systems to the Proposed Scheme, nor any anticipated effects on the risks of flooding from drainage systems within the study area arising from the Proposed Scheme. No specific management measures will, therefore, be required.

7.5 Risk of flooding from artificial sources

- 7.5.1 There are no instances where the Proposed Scheme will be at significant risk of flooding from artificial sources, nor any anticipated effects on the risks of flooding from artificial sources within the study area arising from the Proposed Scheme. No specific management measures will, therefore, be required.

8 Post-development flood risk assessment

8.1 Local receptors

8.1.1 In addition to the risk of flooding that exists to the Proposed Scheme, there is potential for the Proposed Scheme to affect the risk of flooding to third party receptors by altering flow mechanics across the range of flood sources. All local receptors with a potential flood risk are identified in Section 5.2 of this report. For the Proposed Scheme to have an impact on a given receptor the identified pathway for that receptor must be shared by both the subject receptor and the Proposed Scheme with the result that a number of cases can be excluded immediately. Table 5 summarises the shared pathways between the Proposed Scheme and each receptor and identifies cases where no shared pathway exists.

Table 5: Shared flood risk pathways in CFA9

Local receptor	Vulnerability classification as per the NPPF	Pathway	Shared pathway between Proposed Scheme and receptor
Kennel Farm	More vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Groundwater - very high	Groundwater risk from superficial deposits only – no shared pathways.
Parkview Cottages	More vulnerable	Groundwater - high	Groundwater risk from superficial deposits only – no shared pathways.
Lime Farm	More vulnerable	Surface water 30 years - deep Groundwater - high	Groundwater risk from superficial deposits only – no shared pathways.
Little Missenden village	More vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep Groundwater - very high	Groundwater risk from superficial deposits only – no shared pathways.
Chalk House	More vulnerable	Groundwater - very high	Groundwater risk from superficial deposits only – no shared pathways.
Hyde Heath village	More vulnerable	Surface water 200 years - deep	No shared pathway.
Braysgate (No. 1 + 2) and Oakley	More vulnerable	Surface water 30 years - deep	No shared pathway.
Spindle's Farm	More vulnerable	Surface water 30 years - shallow	No shared pathway.
The Green, Hyde Heath	More vulnerable	Surface water 200 years - shallow	No shared pathway.
Bullbaiters Lane	More vulnerable	Surface water 30 years - deep	No shared pathway.
Hyde Farm (land and outbuildings)	Less vulnerable	Surface water 30 years - shallow	Chiltern tunnel northern approach and Hyde Farm access overbridge will be approximately 200m downstream

Local receptor	Vulnerability classification as per the NPPF	Pathway	Shared pathway between Proposed Scheme and receptor
Chapel Farm	More vulnerable	Surface water 30 years - shallow	Chiltern tunnel northern approach and Hyde Farm access overbridge will be approximately 200m downstream
Ballinger Road	More vulnerable	Surface water 30 years - deep	No shared pathway.
Great Missenden village	More vulnerable	River flooding Flood Zone 3 Surface water 30 years - deep	No shared pathway.
Buryfield House	More vulnerable	Surface water 200 years - shallow	No shared pathway.
Aylesbury Road	More vulnerable	Surface water 200 years - shallow	No shared pathway.
Black Horse Cottages	More vulnerable	Surface water 30 years - shallow	No shared pathway.
Town End Farm and Black House public house	More vulnerable	Surface water 30 years - deep	No shared pathway.
Laurel Lodge	More vulnerable	Surface water 30 years - deep	No shared pathway.
The Lodge	More vulnerable	Surface water 30 years - deep	No shared pathway.
Mapridge Cottage	More vulnerable	Surface water 30 years - deep	No shared pathway.

8.1.2 There is also the potential for the Proposed Scheme to change the baseline risk of flooding described in the Section 6 of this report. Though designed such that the probability of the Proposed Scheme flooding in any given year is less than 1 in 1,000, any change to the baseline risk of flooding could impact on the assessment of flood risk to the Proposed Scheme. All cases of flood risk discussed in Section 6 of this report are therefore reconsidered regardless of the presence or otherwise of third party local receptors.

8.2 Impact on risk of flooding from rivers

8.2.1 The route will not cross any Environment Agency Main Rivers or identified watercourses for the full extent within the study area. The extent of the Proposed Scheme within CFAg lies wholly within Flood Zone 1. Consequently, there will be no direct impact on the risk of flooding from rivers within the study area.

8.3 Impact on risk of flooding from surface water

8.3.1 Surface water runoff from all permanent structures will be controlled at source by design using SuDS thereby preventing increased rates of surface water runoff to the local surface water network or above ground receptors. Therefore, the Proposed Scheme will not result in the creation of additional areas of surface water flood risk.

Mantle's Wood

- 8.3.2 At Mantle's Wood the route will cross an area shown on the FMfSW to be at risk of 'deep' flooding from direct surface water runoff during the 1 in 200 years return period (0.5% annual probability) and 'shallow' flooding during the 1 in 30 years return period (3.3% annual probability) rainfall event. The area is associated with a pair of well-defined dry valleys that combine immediately upstream of the Proposed Scheme.
- 8.3.3 At this location the Proposed Scheme will be in cutting. Surface water flows from the dry valleys will be intercepted by the Proposed Scheme land drainage, which will carry flows south along the crest of the cutting before descending into a 250m long, 1350mm diameter drop inlet culvert beneath the route, to a balancing pond on the downstream side.
- 8.3.4 There are no formal receptors within the area at risk from this source. As a result of the design of the land drainage system and attenuation features, the Proposed Scheme will have no significant effect on the risk of flooding from surface water at the Mantle's Wood valley crossing.

Farthings Wood

- 8.3.5 At Farthings Wood the route will cross an area shown on the FMfSW to be at risk of 'deep' flooding from direct surface water runoff during both the 1 in 200 years and 1 in 30 years return period (0.5% and 3.3% annual probability) rainfall events. The area at risk is associated with three dry valleys that converge immediately upstream of the Proposed Scheme. Approximately 50m north-east of the main valley crossing the route crosses the western valley a second time with areas of 'shallow' (between 0.1m and 0.3m in depth) flooding shown on the FMfSW in both return period events.
- 8.3.6 Surface water flows from the dry valleys will be intercepted by the Proposed Scheme land drainage. Flows from the east side of the Proposed Scheme will be collected and discharged beneath the route within a 1350mm diameter culvert. Flows arising from the west side of the Proposed Scheme, including flows from the western dry valley will be diverted south-east along the eastern edge of the Proposed Scheme to the base of the main valley. A new channel is to be cut along the base of the valley leading to an attenuation pond some 300m downstream of the Proposed Scheme at the far extent of the woodland near Broome Farm.
- 8.3.7 The Hyde Farm access track and footbridge will also cross all three dry valleys. The overbridge will be raised on embankments to pass over the route and has access limbs that run alongside the route on both sides. Culverts are proposed at all dry valley crossings to maintain continuity of flows.
- 8.3.8 There are no formal receptors within the area at risk from this source. As a result of the design of the land drainage system and attenuation features the Proposed Scheme will have no significant effect on the risk of flooding from surface water at the Farthings Wood valley crossing.

8.4 Impact on risk of flooding from groundwater

- 8.4.1 The bedrock geology within the study area mostly consists of the Chalk aquifer present under much of the Chilterns area. Although this is a principal aquifer the Proposed Scheme within CFAg is mostly above the predicted water level in the aquifer. For just under 1km the Chiltern tunnel may be below groundwater levels. The scale of the tunnel, however, in relation to the depth and extent of the Chalk aquifer means that groundwater levels are unlikely to be significantly affected by the Proposed Scheme. The superficial deposits in the area are unproductive. More detail on the hydrogeology within the study area is provided in the CFAg Water Resources Assessment (Volume 5: Appendix WR-002-009). The Proposed Scheme is not expected to have any significant impact on the risk of flooding from groundwater.

8.5 Impact on risk of flooding from drainage systems

- 8.5.1 The route will not pass through any urban areas for the full extent within the study area. All highway crossings required will be diverted or redesigned as bridges or underpasses. Highway drainage for all new or realigned roads will be designed in accordance with the relevant design guides and regulations and, consequently, no increase in the risk of flooding arising from overloaded highway drains is anticipated.

8.6 Impact on risk of flooding from artificial sources

- 8.6.1 The route will not cross any areas shown on the Environment Agency RIM to be at risk of flooding in the event of impounded reservoir failure. Consequently, the Proposed Scheme will not affect the risk of flooding from this source within the study area.

8.7 Summary of potential impacts and effects on flood risk

Table 6: Summary of potential flood risk impacts and effects in CFAg

Receptor	Vulnerability classification	Pathway	Impacts and effects
General Proposed Scheme	N/A	River flooding	No significant effects expected.
		Surface water	Potential minor localised changes in flow and flood mechanism due to collection of surface water flows into formal drainage systems. No significant effects.
		Groundwater	No significant effects expected.
		Drainage systems	No significant effects expected.
		Artificial sources	No significant effects expected.
Hyde Farm (land and outbuildings)	Less vulnerable	Surface water 30 years - shallow	No significant effects expected.
Chapel Farm	More vulnerable	Surface water 30 years - shallow	No significant effects expected.

9 Conclusions

9.1 Summary

9.1.1 The Proposed Scheme within CFA9 extends from the A413 to the north of the River Misbourne between Mill End and Hyde Heath, to Leather Lane to the south of Hunt's Green. The study area includes all areas within 1km of the Proposed Scheme which includes areas at risk of flooding from various sources as follows:

- areas at risk of flooding arising from surface water runoff; and
- areas susceptible to groundwater emergence within superficial deposits and thus at risk of groundwater flooding.

9.1.2 There are some areas at risk of flooding from surface water runoff where the Proposed Scheme will be less than 1m above ground levels. These areas will be managed by the provision of sufficient capacity in the drainage system of the Proposed Scheme to collect, attenuate and discharge surface water to a suitable outfall. Design standards are such that no flooding of the Proposed Scheme is expected under normal operating conditions.

9.1.3 The dominant land use within the study area is agriculture. There are no instances where significant impacts on the risk of flooding, either from rivers, surface water or groundwater, are expected within the study area.

9.1.4 There are no areas where additional specific mitigation for risks of flooding to the Proposed Scheme or for impacts arising would be required.

9.2 Residual flood risks to Proposed Scheme

9.2.1 Residual flood risks arise in situations that are not included in standard design scenarios, or where infrastructure fails, for example when a culvert becomes blocked causing flooding upstream. Consequently, there may be areas where the potential severity of flooding may exceed the design standard under certain circumstances.

Residual flood risks from rivers

9.2.2 The route will not cross any rivers within the study area and, consequently, no residual risks arise to the Proposed Scheme.

Residual flood risks from surface water

9.2.3 All culverts within the Proposed Scheme are designed with a minimum internal headroom of 600mm above the design flood water level to minimise the risk of blockage. There is not expected to be any significant increased risk of flooding at minor watercourses and dry valley crossings arising from potential blockage of new culverts.

9.2.4 All land drainage is designed to convey the full design flow, without reference to upstream flow restrictions and, as a consequence, the capacity of the land drainage should not be exceeded in such an event. At Mantle's Wood there is a residual risk of flooding into the tunnel portal should the cut-off drain fail.

- 9.2.5 Failure of existing upstream infrastructure could result in higher flood peaks than those calculated due to sudden release of floodwaters. At all locations, however, the Proposed Scheme is at least 1m above the existing ground levels and any residual risk to the Proposed Scheme will therefore be negligible.

Residual flood risks from groundwater

- 9.2.6 Groundwater levels rise and fall relatively slowly and for any change to occur in the risk of flooding from this source abnormal below ground intervention is required. The risk of flooding from groundwater is already considered and there are no residual risks arising from this source.

Residual flood risks from drainage systems

- 9.2.7 Blockage of underground surface water collections systems can cause surcharge and associated flooding. There are no risks of flooding to the Proposed Scheme from drainage systems associated with existing infrastructure within the study area.

Residual flood risks from artificial sources

- 9.2.8 There is no significant risk of flooding from artificial or surface water bodies to the Proposed Scheme or nearby land, therefore, no residual risks arise.

9.3 Residual effects of the Proposed Scheme on flood risk

- 9.3.1 The Proposed Scheme will not affect the risk of flooding from rivers, groundwater or artificial water bodies within the study area. All surface water collection systems are designed with sufficient capacity to convey the 1 in 100 years return period (1% annual probability) rainfall event with allowances included for climate change, siltation and blockage, thereby minimising both the likelihood of and any effect arising from blockage of new surface water collection infrastructure.
- 9.3.2 Surface water discharges from the vent shaft and portal buildings will be attenuated to avoid increasing the load on existing water collection systems and will therefore not increase the potential effect of any residual flooding arising from blocked drainage ditches. There will therefore be no significant residual impacts arising from the Proposed Scheme on the risk of flooding to third parties.

9.4 Compliance with local planning policy

- 9.4.1 The Proposed Scheme includes an allowance for future increases in the risk of flooding as a result of climate change by adding a 20% increase to design river flows and a 30% increase to rainfall intensities and flows in minor watercourses as recommended in the NPPF Technical Guidance document. SuDS, in the form of attenuation ponds and swales, as well as the creation of open channel land drainage, are used throughout the design. The Proposed Scheme will be in compliance with the BuCCLFRMS. The ChDC Core Strategy focusses largely on the risk of flooding from rivers but also covers risks from surface water. The use of SuDS in the design is in accordance with the ChDC Core Strategy.

10 References

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